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PO Box 1663 MS H816
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| Author(s): | E.-I. Esch, J. L. Ullmann, R. Reifarth, R. C. Haight, J. M . O'Donnell, R. S. Rundberg, D. J. Vieira, T. A. Bredeweg, J. M. Wouters, E. J. Pitcher<br>Los Alamos National Laboratory | | |

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|---|---|---|---|
| Principal Author: | Ernst I. Esch | 3/31/04 | |
| LANL Program Manager: | Michael W. Cappiello | 3/31/04 | |
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# Memorandum

*LANSCE-3*
*Neutron and Nuclear Science*

*To/MS:* Michael W. Cappiello / H816
*From/MS:* Ernst Esch / H855
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**SUBJECT: Preliminary Analysis of NP-237 Capture Cross Section**

**E.-I. Esch, J. L. Ullmann, R. Reifarth, R. C. Haight, J. M . O'Donnell**
Lansce-3 Los Alamos National Laboratory, Los Alamos, New Mexico

**R. S. Rundberg, D. J. Vieira, T. A. Bredeweg**
C-INC Los Alamos National Laboratory, Los Alamos, New Mexico

**J. M. Wouters**
IM-8 Los Alamos National Laboratory, Los Alamos, New Mexico

**E. J. Pitcher**
Lansce-12 Los Alamos National Laboratory, Los Alamos, New Mexico

Neptunium-237 is a major constituent of spent nuclear fuel. Estimates place the amount of Np-237 bound for the Yucca Mountain high-level waste repository at 40 metric tons. The Department of Energy's Advanced Fuel Cycle Initiative program is evaluating methods for transmuting the actinide waste that will be generated by future operation of commercial nuclear power plants, thereby reducing or possibly eliminating the need for a second repository beyond Yucca Mountain. The critical parameter that defines the transmutation efficiency of actinide isotopes is the neutron fission-to-capture ratio for the particular isotope in a given neutron spectrum. The calculation of transmutation efficiency therefore requires accurate fission and capture cross sections over the range of neutron energies in both the reactor in which the actinides are produced (typically thermal systems) and the transmuter (most likely a fast spectrum system). Current Np-237 evaluations available for transmuter system studies show significant discrepancies in both the fission and capture cross sections in the energy regions of interest. Therefore, the Np-237 capture cross section was measured with DANCE, and the preliminary Results are presented in this memo.

DANCE, the Detector for Advanced Neutron Capture Experiments, is a 162 element $4\pi$ $BaF_2$ gamma-ray calorimeter located on the 20 m long Flight Path 14 at the Lujan Center. The detector was designed to make measurements of neutron capture reactions on very small quantities, on the order of 1 mg, of rare or radiactive nuclides. The detector was completed in 2003. Studies of the detector's gamma-ray energy resolution, experimental backgrounds, efficiency, and measurements of the beam flux on the flight path were made.

Measurements of the neutron capture on $^{237}$Np have been carried out. The Np-237 measurement is the first radioactive target in DANCE to generate capture cross sections. The target was produced by the C-INC group at LANL. Radiation from the decay of the $^{233}$Pa daughter would make handling and measurements difficult, so the $^{237}$Np was chemically purified just prior to electrodeposition.The purified neptunium was electroplated onto two 2.5 micrometer thick titanium foils. These two foils were put facing each other with the Np plated side into DANCE. The total amount of Np plated on the foil was approximately 0.7 mg. $^{237}$Np is a difficult 2.14 x $10^6$ year half-life alpha emitter which decays to the short-lived nuclide $^{233}$Pa. Because of the problems handling an alpha-emitting actinide, a special secondary container with thin kapton windows was developed (Figure 1).

**Figure 1: Picture of the Radioactive Target Holder used for the $^{237}$Np measurements.**

Different time of flight measurements were taken to cover the energy region of 10 meV to 200keV. The preliminary data analysis focused on the data in the 20meV to 100eV region. The data files were analyzed and a 2D histogram displaying neutron energy versus total gamma energy was extracted from the data file. This was done for the sample data as well as the data from an empty container. The 2D Histogram was then sliced into neutron energy bins with a width of 1%. The resulting gamma energy histograms were then fitted in the energy region above the Q-value (5.8MeV) of the Np. Thus the remainder of the spectrum only contained elastic scattering effects. The spectra were normalized to the tails and subtracted from each other. An integral over the region of the Q-value peak, 3.5 MeV and 6 MeV was calculated and

used as yield for each bin in the time of flight spectrum. This spectrum was divided by the measured neutron fluence.

The resulting cross section plot was fit to the dominant resonance in the Np spectrum. Figure 2 shows the measured data with the ENDF and JENDL evaluation. Since the preliminary result only represents a fraction of the data, no errors were calculated.

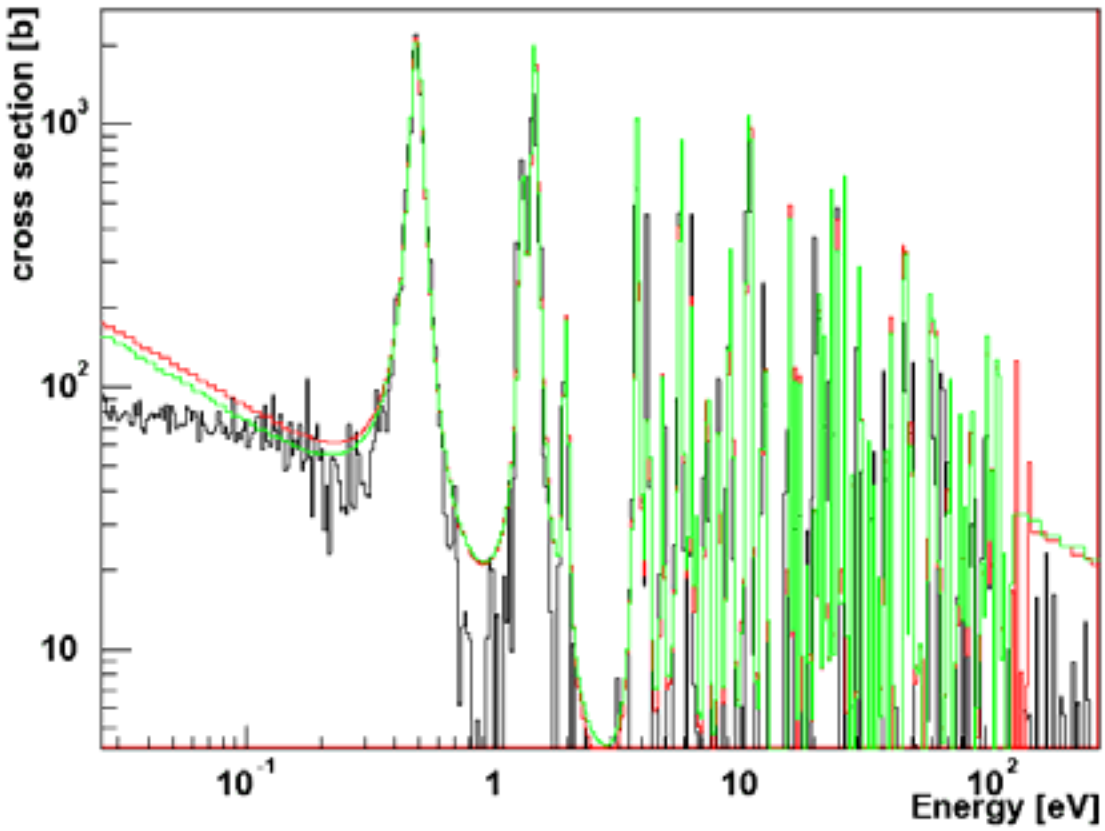


**Figure 2: Measured data (black) ENDF IV (red) JENDL (green)**

c. Stephen Wender, LANSCE-3, MS H855
Eric Pitcher, T-16, MS B243
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